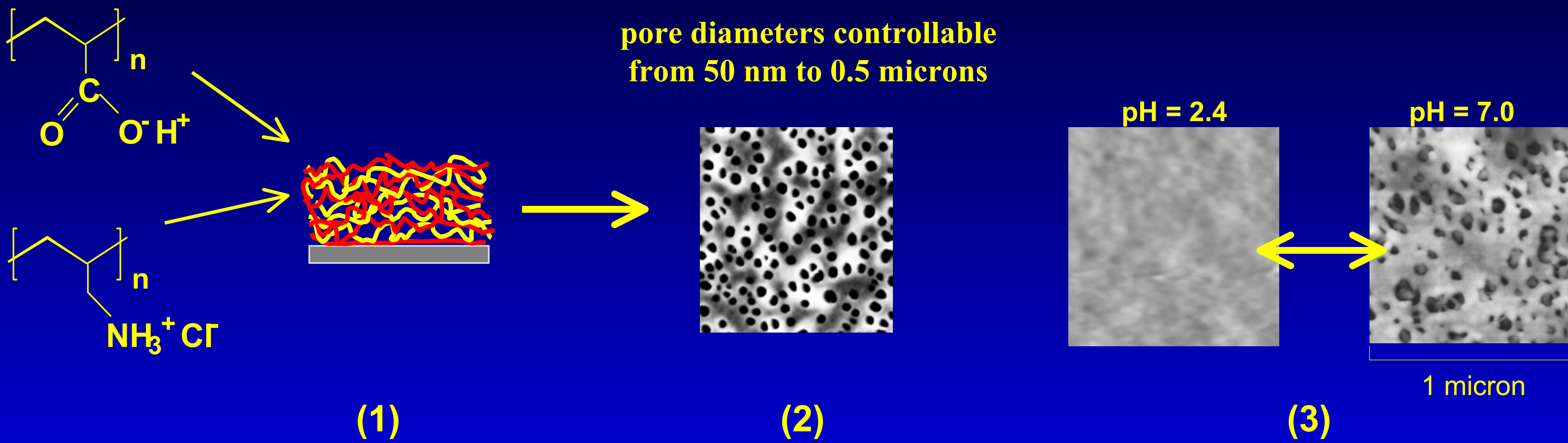
Reversibly Erasable Nanoporous Thin Films

MIT MRSEC



1) Oppositely charged polymers are assembled onto surfaces from water one molecular layer at a time to create a thin film known as a polyelectrolyte multilayer.

2) The multilayer thin film is then transformed into a porous thin film by simply immersing it into acidic water followed by a rinse with neutral water.

3) The nanopores can be reversibly opened and closed by dipping the film into acidic or neutral water. Using this approach, the refractive index of the coating is tunable from ~ 1.1 to 1.5. The low index films are ideal for use as anti-reflection coatings.

Explanation

Porous films are important in many applications ranging from optics to filtration to biomaterials. In optics, nanoporous films are used to eliminate unwanted surface reflections due to the fact that, being filled with air, they have a lower refractive index than typical optical substrates. Nanopores, in turn, are needed to prevent light scattering from the pores. Within the MIT MRSEC, we have discovered a very simple, low cost method for making porous thin films with pore sizes controllable from the micro- to nanometer scale. The nanoporous films can also be reversibly converted from a porous to nonporous state by simple water treatments making them useful for drug delivery and pH-controlled filtration applications. The nanoporous films can also be "locked-in" permanently and used as a low cost anti-reflection coating for plastics and glass (see next slide).

Content Institute
Dust Busting by Design: Applying the Engineering Design Process

MIT MRSEC

Sponsoring Partners: Massachusetts Department of Education and Cambridge Public School Science Department

Objectives

- Better prepare educators to teach the engineering design process through direct experience designing and building a motor for a hand-held vacuum cleaner
- Deepen teachers' knowledge of the science and engineering of the materials involved
- Develop engineering modules for classroom use

Participants

- 18 Massachusetts middle and high school science teachers
- 27 10th and 11th grade women

Program (six days)

- Introduction to the design features of a hand-held vacuum cleaner and its motor
- Faculty presentations and demonstrations on the major materials involved: batteries, magnets, and polymers
- Three days in the lab designing and building motors
- Testing, evaluating, and trouble-shooting the motors built
- Teachers create design modules for their students and present them to the rest of the group
- Modules are documented and distributed via the internet

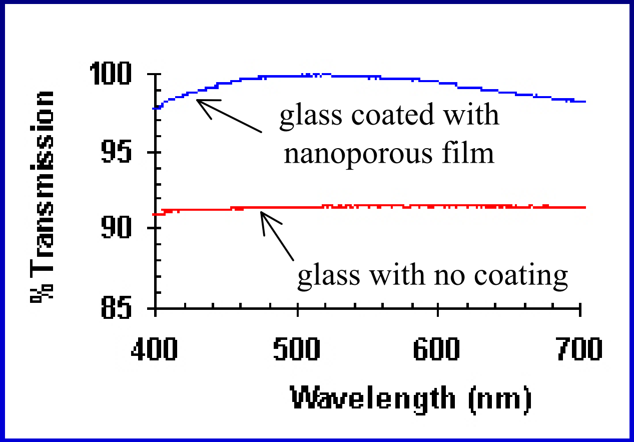
Content Institute
More Interesting Facts

1. The program was funded collaboratively with the Massachusetts Department of Education as one of 52 Content Institutes (12 in science) designed to increase the content knowledge of teachers and, thereby, raise student achievement. This program was designed to specifically address the "Engineering Design Process" state learning standard. Cambridge teacher Karen Spaulding worked with Prof. Steven Leeb of the MIT MRSEC to develop this institute.
2. The participating teachers work in eastern Massachusetts school districts, representing a very diverse student population.
3. The 27 high school students who participated in the three-day motor design and construction portion of this institute were at MIT for a four-week Women in Technology Program offered by the Department of Electrical Engineering and Computer Science. The WTP program was inaugurated in the summer of 2002 with the intention of encouraging young women to pursue electrical engineering. The participants were drawn from throughout the US.
4. On the fifth day of the program, the teachers created outlines of the design challenges they are creating for classroom use and ordered most of the supplies needed. On August 26th, they will reconvene to present the modules to each other and fine tune them.

MIT MRSEC

Nanoporous Anti-Reflection Coatings

Technical implications: potential applications include; low cost, environment friendly anti-reflection coatings for plastic and glass optical components and displays, controlled drug release, pH-controlled membranes and filters, and self-cleaning surfaces.



The transmission of light through glass and plastic optical elements can be increased dramatically by reducing reflective losses.

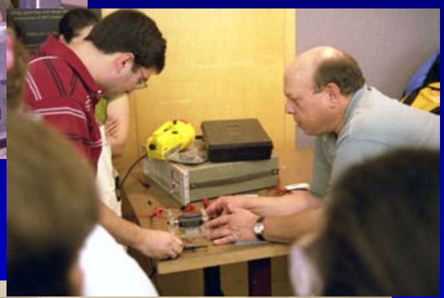
Educational implications: The ease of producing these nanoporous coatings using only water-based processing makes them ideal teaching vehicles for basic principles of chemistry and physics. Currently, MRSEC supported graduate student Jeri-Ann Hiller and RET participant Steve Rhule (Delaware Valley High School) are developing laboratory modules for high school students. Modules based on these materials have also been introduced into undergraduate labs at MIT.

The image shows a glass slide that was patterned with an ink-jet printer (using water as the ink) to create regions coated with the nanoporous film (no reflection of light) and regions not coated (strong gold reflecting regions). The plot shows that the coated regions transmit more light (at some wavelengths close to 100%) than the uncoated regions. Optical grade glass and plastics typically reflect about 8% of incident light resulting in poor image quality in displays and low efficiencies in solar cells, for example. The simplicity of this process and the fact that it can be accomplished using water makes it ideal for high school laboratories and classroom demonstrations.

MIT MRSEC

Content Institute

Dust Busting by Design: Applying the Engineering Design Process



Teachers with more confidence and stronger content understanding

"This program empowered me." - *middle school science teacher*

Impact

New partnerships

"What was most valuable was the process by which we did this: learn, design, build, test, redesign. I may not make a motor in my class, but now I know how to approach a design problem." - *middle school science teacher*

Ideas and material for classroom teaching

1. Teachers left the program feeling far more confident about teaching engineering and design because they experienced it firsthand. For instance, many will be teaching units that require their students to design solar cars, and they expressed that they feel much better prepared to do so as a result of this program.

2. Over the course of the week spent working together on the MIT campus, new collaborations were formed between teachers from different school districts. In addition, conversations were begun between CMSE and teachers from a variety of school districts about possible future workshops. Also, a number of the participants plan to apply to the RET program at CMSE.

3. RET participant Sean Müller presented his approach to teaching about polymers at the high school level and distributed a toolbox of polymer classroom demonstrations to each teacher

4. The final step in this program is for the teachers to design classroom design modules. Once they are prepared and have been tested in the classroom, the group intends to share these modules with other educators via the internet.